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Differences in Vegetation Biomass and Structure Due to Cattle Grazing in a Northern Nevada Riparian Ecosystem

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RESEARCH SUMMARY

Plant biomass and structure on an area seasonally grazed by cattle was compared to that on a comparable adjoining area fenced from grazing for the previous 11 years. The study was on the West Fork of Deer Creek in northeastern Nevada. Differences between the grazed and ungrazed situations were compared for the riparian plant community complex—aspen (*Populus tremuloides*)/willow (*Salix* spp.)/Kentucky bluegrass (*Poa pratensis*)—and for the adjacent steep upland community—big sagebrush (*Artemisia tridentata*)/upland. Less graminoid biomass and height, but more nonwillow large shrub biomass and more soil compaction were the most obvious effects of cattle grazing within the riparian plant community complex. Relatively little grazing of the adjacent upland occurred, and few grazing effects were measured. Aspen stands were relatively similar on the grazed and the ungrazed areas, implying that recent levels of grazing have not greatly affected aspen regeneration. On an adjacent supplemental study area, very heavy grazing had a major impact on aspen regeneration and stand structure. Most of the plant biomass across the entire study area was contributed by down, dead aspen drowned by flooding from a series of now-abandoned beaver dams.

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INTRODUCTION

Riparian areas in western North America are generally associated with drainage courses and thus are usually elongate. Water, nutrients, sediments, and organic matter tend to concentrate in the riparian areas (Coston and others 1978). These elements permit development of plant communities that are more diverse and more productive than those of surrounding uplands. Though small in aggregate area, riparian areas serve as islands of diversity in regional landscapes. Plant communities within riparian areas are often arranged in complex mosaics associated with soil and hydrologic variation (Thomas and others 1979; Tuhy and Jensen 1982).

Riparian ecosystems have certain attributes that constitute important wildlife habitat (Thomas and others 1979). Water, food, and cover in close proximity and in kinds and amounts not found nearby produce relatively high densities and diversities of animal species (Carothers and others 1974; Compton and others 1988; Hubbard 1977). The vegetation along small and intermediate-sized streams helps control physical conditions in the stream environment. The roots stabilize streambanks, retard erosion, and influence bank morphology while aboveground vegetation slows highwater streamflow and sediment and detritus movement, and is a source of large organic debris for streams (Jahn 1978; Meehan and others 1977).

Given the opportunity, most domestic livestock, such as cattle, will spend a disproportionate amount of time in riparian areas as compared to adjacent xeric upland areas. The time spent may be five to 30 times longer than expected based on extent of the riparian area. This often leads to overgrazing of the riparian community (Skovlin 1984). Reductions of riparian herbage standing crop by grazing livestock vary greatly. Platts (1982) reported that herded sheep may reduce herbage in the riparian area by only a negligible amount. The amount of herbage removed by cattle may be in the moderate range on high mountain meadows (interpreted from Platts and Nelson 1986) to nearly 100 percent in a riparian area transecting the semiarid big sagebrush zone (Platts and Nelson 1984). Severe overgrazing is almost invariably detrimental to herbaceous and woody plant communities, but only limited information is available concerning the effects of well-managed grazing on riparian plant communities (Clary and Webster 1989).

Dramatic vegetation successional changes can occur when the grazing stress is removed. If habitat deterioration is not severe, herbaceous vegetation can greatly increase within several growing seasons (Platts and Nelson 1984), and woody vegetation can rebound within 5 to 10 years (Rickard and Cushing 1982; Skovlin 1984). But severe habitat deterioration can require very long recovery times, perhaps decades (Knopf and Cannon 1982) or more (Platts and Raleigh 1984).

Studies conducted on Deer Creek in northern Nevada have previously shown that grazing at a moderate to heavy rate, although not at an extreme rate, resulted in no change in nesting bird populations but did result in a reduction of small mammal populations as compared to an ungrazed exclosure (Medin and Clary 1989 and in preparation). Fish populations in the same area were little different from the ungrazed exclosure, although certain fishery habitat characteristics had been changed by the grazing (Contor and others 1989; Crispin 1981; General Accounting Office 1988).

For a similar area on Deer Creek as reported in the studies above, this paper documents the vegetation characteristics of the grazed and ungrazed riparian community complex (Winward and Padgett 1989) and an adjacent xeric sagebrush community. An additional supplemental study of aspen stand characteristics was made on a nearby area annually subjected to very heavy grazing.

STUDY AREA

The study area is on the West Fork of Deer Creek in northeastern Nevada. The Deer Creek site is at an elevation of approximately 1,890 m, 55 km north of Wells, NV. The small stream originates from springs and flows in a narrow, V-shaped canyon cut into mid-Tertiary rhyolitic rock. Average gradient of the canyon bottom is 2 to 3 percent. Soils are generally fine-textured, ranging from shallow on steep residual slopes to very deep on relatively level alluvial fans and floodplains (Platts and others 1988). The riparian areas seldom exceed 25 to 50 m in width.

The stream was closely bordered by clumped stands of aspen, willow, and other deciduous shrubs—primarily currant (*Ribes* spp.), Woods rose (*Rosa woodsii*), and snowberry (*Symphoricarpos* spp.). The gallerylike riparian area appeared as an island surrounded by an upland plant community dominated by big sagebrush but also included rubber rabbitbrush (*Chrysothamnus nauseosus*) and antelope bitterbrush (*Purshia tridentata*).

The herbaceous component within the riparian complex included Kentucky bluegrass, bluebunch wheatgrass (*Agropyron spicatum*), slender wheatgrass (*A. trachycaulum*), sedge (*Carex* spp.), mannagrass (*Glyceria* spp.), Baltic rush (*Juncus balticus*), horsetail (*Equisetum arvense*), common yarrow (*Achillea millefolium*), aster (*Aster* spp.), yellow sweetclover (*Melilotus officinalis*), clover (*Trifolium* spp.), and lupine (*Lupinus* spp.). Typical species on the adjacent upland are bluebunch wheatgrass, Sandberg's bluegrass (*Poa secunda*), cheatgrass (*Bromus tectorum*), Indian paintbrush (*Castilleja* spp.), balsamroot (*Balsamorhiza* spp.), and wild buckwheat (*Eriogonum* spp.).

Narrow floodplains with dead and downed aspen are common in the study area. These remnants of aspen communities were once flooded by beaver impoundments that drowned the trees. Numerous washed-out dams are evident, but beaver no longer inhabit the study area.

Eight major and several minor vegetation community types have been identified in the Deer Creek riparian area and adjoining upland (Platts and others 1988). The big sagebrush (*Artemisia tridentata*)/upland type occupied the steep canyon slopes. The remaining types were considered as components of a riparian complex typified by aspen (*Populus tremuloides*), willow (*Salix* spp.), and Kentucky bluegrass (*Poa pratensis*). A riparian complex represents a unit of land that supports or may potentially support a similar grouping of community types (Winward and Padgett 1989). A formal description and designation of the riparian complex(es) on Deer Creek was beyond the scope of this investigation.

The primary study was conducted within a large (40+ ha) cattle exclosure, fenced 11 years previously (trespass grazing did occur on several occasions) and on an adjacent area selected on the basis of topographical and vegetational similarities with the enclosed area. The construction of the exclosure across the narrow Deer Creek canyon served as a drift-fence reducing the cattle use of the grazed portion of the primary study area (upstream side of the exclosure), as compared to previous years. Grazing on a supplemental study area immediately downstream from the exclosure has continued to be very heavy (approximately 90 percent herbage removal).

These public lands, managed by the Bureau of Land Management, are usually grazed from about mid-August to mid-November. Because of weather conditions, grazing in the year of study was mid-July to mid-October (Phillips and Marteney 1989).

METHODS

The rectangular cattle exclosure, about 965 m long and of variable width, is oriented lengthwise along the West Fork. Two 600- by 150-m plots, one in the upper section of the exclosure and the other in the adjoining (upstream) grazed area, were sampled for vegetation and other characteristics from August 15 to September 2, 1988. For each of the grazed and ungrazed situations, the riparian complex contained 60 sample locations, and the adjacent steep upland site contained 12 sample locations. A 50- by 50-cm (0.25-m^2) quadrat was located at each of the systematically positioned sample locations. Canopy cover (Daubenmire 1959) was ocularly estimated for the total of each plant life form (graminoid, forb, shrub) and recorded in percentage as the midpoint of one of eight cover classes (0-1, 1-5, 5-10, 10-25, 25-50, 50-75, 75-95, 95-100). Percentages of litter, rock, bare ground, and lichen-moss were similarly estimated. The vegetative height (excluding flower and seedhead heights) of each graminoid, forb, and shrub nearest the center of each quadrat was recorded.

Biomass of graminoids, forbs, and small shrubs was determined by clipping vegetation from ground level upward within a vertical projection from the 0.25-m^2 quadrats. Clipped materials were bagged, ovendried, and weighed. A 3- by 3-m (9-m^2) plot, concentric to each 0.25-m^2 quadrat, was used to sample biomass of large shrubs. Basal diameter, maximum height, and species were recorded for each shrub stem rooted within the plot. For willow clumps, average stem diameter and average stem height were recorded instead of individual stems. Biomass of willows, bitterbrush, rose, currant, snowberry, oceanspray (*Holodiscus dumosus*), and serviceberry (*Amelanchier alnifolia*) was estimated by use of the equations of Brown (1976). Height and diameter at breast height (d.b.h.) were recorded for each tree stem rooted within 10- by 10-m (100-m^2) plots concentric to each 0.25-m^2 quadrat. Biomass of aspen was estimated by the Chicken Creek equations of Bartos and Johnson (1978).

Biomass of downed woody material was sampled midway between the vegetation sample locations. The methodology used was similar to Brown (1974) except that there were no corrections for slope and no measures of fine litter and duff. Samples of downed woody material were collected for determination of moisture content. All biomass data in this study are reported as grams per square meter ovendry.

Unconfined soil compressive strength (index of bulk density) was measured in opposing corners of the 0.25-m^2 quadrats with a pocket penetrometer, averaged, and recorded. The corners were selected to best represent mineral soil, that is, soil surface not covered by heavy litter or duff, or rock. The readings were taken immediately upon selection of the sample location before plant sampling activities impacted the soil surface. On the supplemental study area all aspen stems were recorded by size class in two adjacent 40- by 40-m plots—one very heavily grazed and one within the downstream end of the cattle exclosure.

Differences between the two primary treatment areas were tested for significance by unpaired t-test.

RESULTS AND DISCUSSION

We look at four topics in our study results: herbaceous and shrub vegetation; aspen; overstory-understory relationships; and plant biomass distribution.

Herbaceous and Shrub Vegetation

Riparian Complex—The greatest differences between the primary grazed and fenced situations were in the graminoids, as expected because graminoids normally constitute the dominant portion of cattle diets. Grass standing crop biomass in the grazed situation was only

Table 1—Plant biomass—riparian community complex

	Biomass (g/m²)						
	Grazed			Ungrazed			
Plant group	Live	Dead	Total	Live	Dead	Total	*P* (totals)[1]
Grass	74.5	23.7	98.2	131.3	65.1	196.4	<0.01
Forb	13.3	0	13.3	16.5	0.1	16.6	.20
Total herbage	87.7	23.7	111.5	147.8	65.2	213.0	<.01
Small shrub							
Foliage	18.6	—	18.6	13.8	—	13.8	.44
Wood	24.8	11.7	36.5	23.4	3.1	26.5	.43
Total	43.4	11.7	55.1	37.2	3.1	40.3	.42
Large shrub							
Willow							
Foliage	63.3	—	63.3	73.9	—	73.9	.74
Wood	646.8	9.8	656.6	1,810.9	5.6	1,816.5	.41
Total	710.1	9.8	719.9	1,884.8	5.6	1,890.4	.41
Nonwillow							
Foliage	128.1	—	128.1	6.2	—	6.2	.01
Wood	440.3	10.0	450.3	8.3	13.8	22.1	.06
Total	568.4	10.0	578.4	14.5	13.8	28.3	.04

[1] *P* of less than 0.10 was considered significant.

about 50 percent of that in the fenced situation (table 1). Likewise, vegetative grass heights differed significantly between the two treatments (table 2). The differences in grass biomass and heights seemed predominantly due to recent livestock grazing rather than to a basic difference in plant growth between the two areas. Forbs exhibited less difference in standing crop biomass and vegetative plant height than did the graminoids.

There were no significant differences in characteristics of small shrubs such as sagebrush between the grazed and fenced areas. There was, however, a large difference between the calculated means of the willow standing crop biomass, but the significance was masked by the extreme variation among samples. The biomass attributed to large shrubs other than willow (currant, rose, snowberry, and so forth) was significantly higher in the grazed situation. Although one cannot be sure whether this is a response to site or grazing differences, Elmore (1988) described currant as replacing willow and alder when water tables are lowered in response to grazing or other stresses on the stream channel. Presumably, the reverse may also be true, so that if water tables rise in response to reduced erosion stress and to narrowing of the stream channels, willows may replace currant or rose or other plants.

There was little difference in the number of species per plot between grazed and ungrazed situations; thus grazing has not measurably affected overall plant diversities. Nevertheless, the grazed herbaceous plant compositions appeared by observation to contain more Kentucky bluegrass in the riparian complex and more annuals in the upland compared to plant compositions in the fenced area. The ground cover characteristics were similar between the two areas except for slightly more bare soil where grazing had occurred. Soil strength readings were significantly different, indicating that the soils were more compacted on the grazed area. This characteristic could result in reduced plant growth and greater surface water flow, thereby creating a drier site and increased erosion potential (Branson and others 1981).

Adjacent Upland—As expected, the adjacent xeric steep upland sites received less grazing use than the riparian area (Myers 1989; Skovlin 1984). Few characteristics were significantly different between grazed and fenced situations, although some possible differences in mean values appeared in this relatively limited sample

Table 2—Ground cover and miscellaneous characteristics—riparian community complex

Item	Grazed	Ungrazed	*P*[1]
Cover (percent)			
Bare	9.6	5.6	0.08
Litter	25.2	29.5	.20
Rock	4.0	2.1	.22
Lichen-moss	.1	<.1	.58
Grass	54.7	56.0	.72
Forb	6.6	7.6	.54
Shrub	5.2	4.2	.59
Plant height (m)			
Grass	.25	.37	<.01
Forb	.12	.16	.06
Shrub	1.46	1.35	.61
Species per 0.25 m²			
Grass	2.40	2.28	.30
Forb	1.37	1.60	.24
Shrub	.43	.33	.36
Soil compressive strength (kg/cm²)	2.05	1.35	<.01

[1] *P* of less than 0.10 was considered significant.

Table 3—Plant biomass—*Artemesia tridentata*-upland community type

	Biomass (g/m²)						
	Grazed			Ungrazed			
Plant group	**Live**	**Dead**	**Total**	**Live**	**Dead**	**Total**	***P* (totals)[1]**
Grass	41.3	9.0	50.3	44.0	10.7	54.7	0.74
Forb	18.7	0	18.7	8.0	0	8.0	.25
Total herbage	60.0	9.0	69.0	52.0	10.7	62.7	.70
Small shrub							
Foliage	64.0	—	64.0	110.3	—	110.3	.48
Wood	44.7	156.0	200.7	200.7	50.3	251.0	.71
Total	108.7	156.0	264.7	311.0	50.3	361.3	.61
Large shrub							
Foliage	76.5	—	76.5	24.8	—	24.8	.14
Wood	612.3	17.3	629.6	241.2	T	241.2	.20
Total	688.8	17.3	706.1	266.0	T	266.0	.19

[1] *P* of less than 0.10 was considered significant.

of upland conditions (12 sample locations per grazing situation). Grass heights were significantly lower under grazing, but the standing crop biomass was not greatly different (tables 3, 4). Numbers of forb species were higher under grazing. This often occurs when grazing reduces the dominant species and allows a more diverse composition to develop (Dobson 1973).

Aspen

Although a grazing management change of only 11 years would not likely affect a stand of large mature aspen trees, it could cause a change in the young age classes of aspen. This is illustrated by data from the primary and the supplemental study areas (fig. 1). The plot grazed very heavily each year had mature and decadent aspen and a number of suppressed sprouts, the majority of which were less than 0.7 m high. However, the moderate to heavily grazed plot and the ungrazed plot in addition had impressive numbers of sapling-sized aspen (up to 9 cm d.b.h. and about 6.5 m tall), the largest of which were dated by tree-ring counts to the year of fence construction.

Removal of grazing normally results in an increase in aspen reproduction (DeByle 1985). The moderation of grazing on the primary grazed site, due to the barrier effect of the exclosure fence in the narrow canyon, appears to have also resulted in an increase in aspen reproduction although in somewhat reduced numbers as compared to the exclosure. These saplings should provide a basis for continuation of the aspen stand after the current mature trees senesce. The total lack of the sapling size class in the very heavily grazed area foretells the eventual loss of this aspen stand under current grazing practices.

Table 4—Ground cover and miscellaneous characteristics—*Artemesia tridentata*-upland community type

Item	**Grazed**	**Ungrazed**	***P*[1]**
Cover (percent)			
Bare	21.9	34.8	0.18
Litter	12.2	8.9	.39
Rock	28.3	21.9	.62
Lichen-moss	0	0	—
Grass	23.0	23.2	.99
Forb	7.8	4.4	.45
Shrub	15.2	19.1	.63
Plant height (m)			
Grass	.19	.30	.04
Forb	.15	.16	.79
Shrub	.89	.66	.17
Species per 0.25 m²			
Grass	1.67	1.58	.69
Forb	.83	.25	.03
Shrub	1.00	.75	.38
Soil compressive strength (kg/cm²)	1.14	.78	.39

[1] *P* of less than 0.10 was considered significant.

Overstory-Understory Relationships

Aspen types are considered to be some of the best-suited vegetation types for joint production of wood and forage (Betters 1983). Overstory-understory relationships that portray the degree of plant competition can provide part of the basis for management strategies in these types. The overstory-understory relationships within the Deer Creek riparian complex appear to be weak, if indeed they exist at all. For instance, aspen density in the ungrazed area accounted for less than 1 percent of the variation in herbage biomass (fig. 2) and less than 2 percent of the variation in shrub biomass. Other research results conflict regarding aspen overstory and understory productivity relationships. Differences in understory plant response to different aspen sites may explain apparently divergent results (Betters 1983).

Because the relationships on Deer Creek are poorly defined, strong competition between plant life forms may

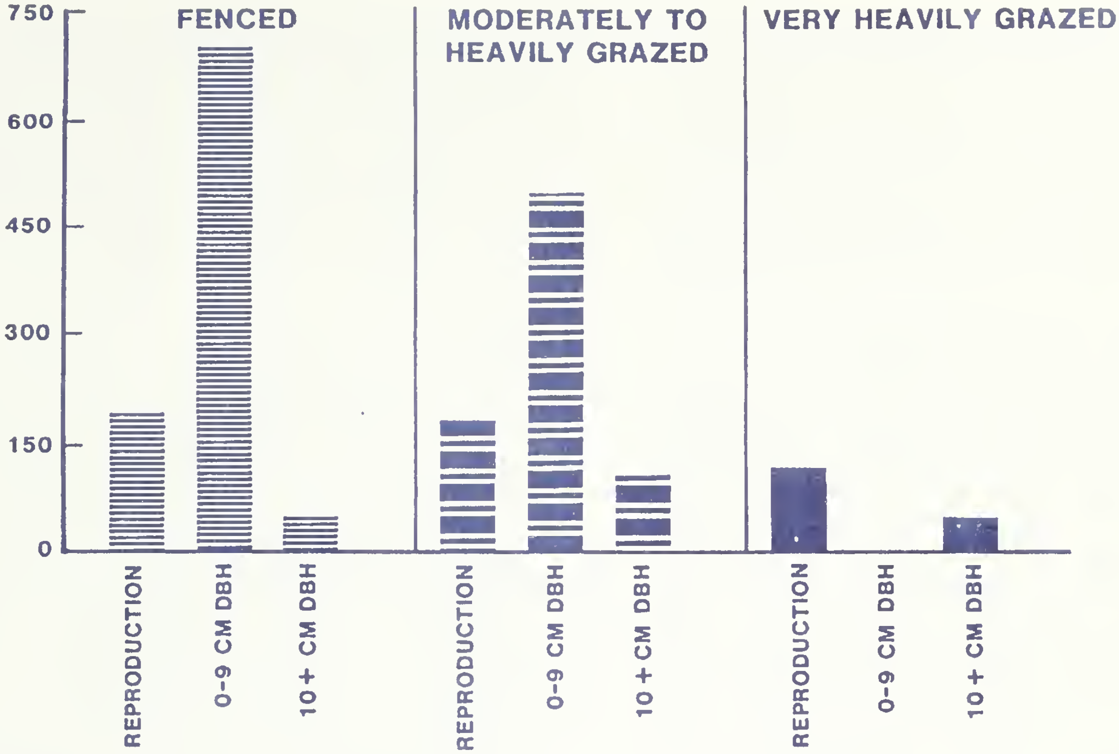

Figure 1—Number of aspen stems related to grazing intensity. Comparison is made between aspen communities within the fenced exclosure, the moderately to heavily grazed primary study area, and the very heavily grazed supplemental study area.

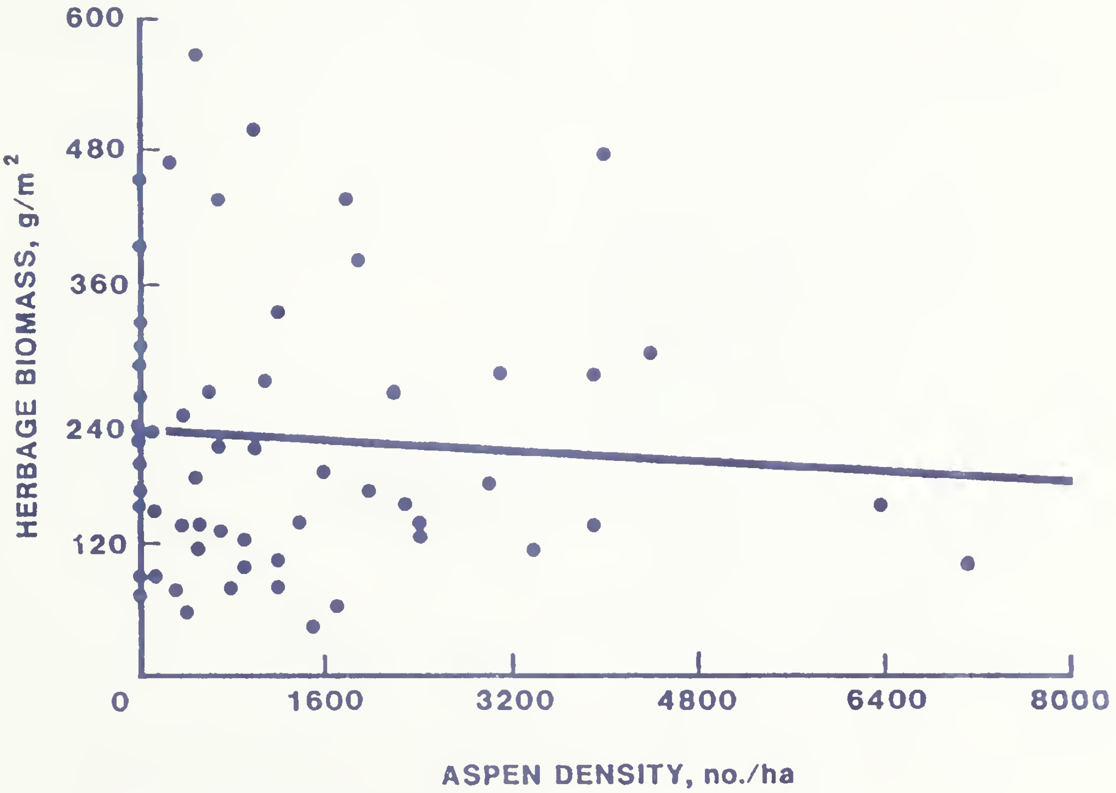

Figure 2—Relationship between herbage biomass and aspen density.

not exist in this riparian area. Medium-textured to fine-textured, deep to very deep soils, and access to a permanent water table may have greatly reduced competition between plant life forms compared to that typically occurring on semiarid and arid habitats (Ffolliott and Clary 1982). Some of the highest herbage biomass values occurred in conjunction with high amounts of willow biomass. A likely reason is the greater moisture availability in sites supporting willow communities (Platts and others 1988).

Plant Biomass Distribution

Figure 3 illustrates the distribution of biomass within the fenced riparian complex and adjacent steep upland on the West Fork Deer Creek study sites. Plant biomass within the riparian complex totaled 10,339.1 g/m^2. The live biomass made up 3,699.3 g/m^2, and of this 271.7 g/m^2 was foliage (nonwoody). Woody biomass, live and dead, constituted 97 percent of the total in this system. The average live aspen biomass, including large mature trees, was estimated to be 1,615.0 g/m^2. Standing dead aspen averaged 560.2 g/m^2, and downed woody biomass averaged 5,991.9 g/m^2. Dead biomass made up 64 percent of the total in the riparian complex.

The plant biomass in the fenced upland sites averaged 1,113.3 g/m^2. Foliage contributed 187.1 g/m^2, and the remainder was live and dead woody material. Down and dead aspen, which had fallen onto the lower portion of the upland sites from the riparian complex, contributed 423.3 g/m^2—38 percent of the total biomass and 87 percent of the dead biomass. Dead biomass was 44 percent of the total.

The amount of standing live biomass has undergone large changes in recent history, particularly in the riparian complex. The downed dead large debris exceeded the current volume of standing trees by several fold. Dead aspen biomass was largely a result of flooding of trees by earlier beaver activity. An apparent cycle occurs: aspen stand development, arrival of beaver, felling or drowning of aspen stands from extensive beaver activity, followed by loss of beaver populations and the subsequent redevelopment of aspen stands. Heavy grazing may short-circuit the cycle by removing aspen reproduction.

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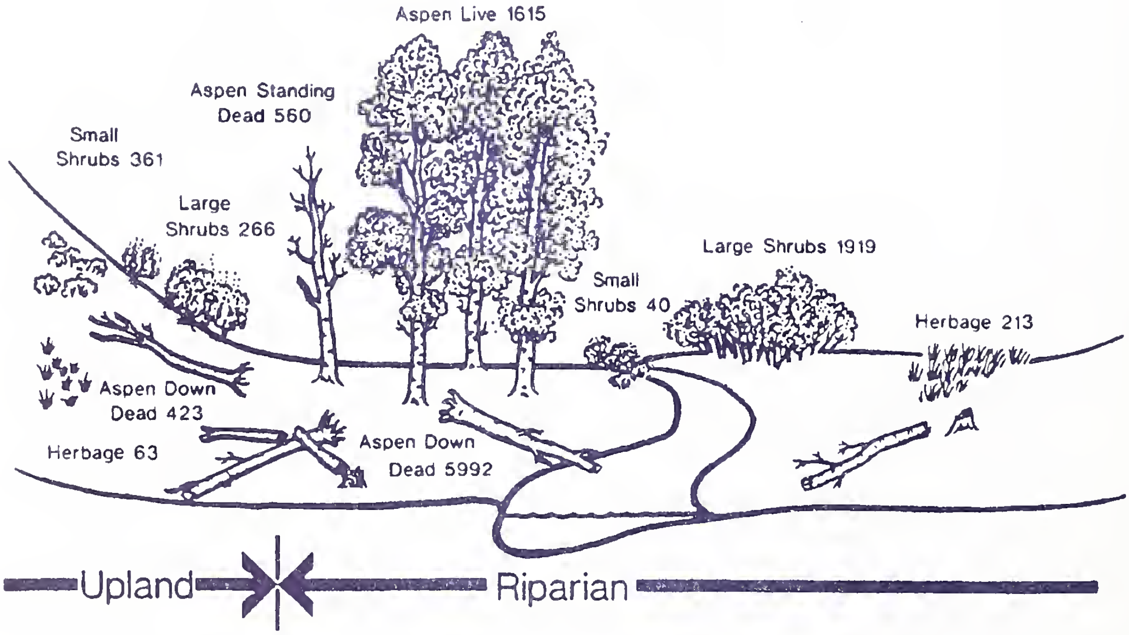

Figure 3—Plant biomass distribution in the fenced area of Deer Creek canyon. Numbers represent grams per square meter ovendry biomass.

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Plant biomass and structure on an area seasonally grazed by cattle was compared to that on a comparable adjoining area fenced for 11 years. In the riparian area less graminoid biomass and height, but more nonwillow large shrub biomass and more soil compaction were the most obvious effects of moderate to heavy cattle grazing. On a nearby area very heavy cattle grazing had a major impact on aspen regeneration and stand structure.

KEYWORDS: *Populus*, *Salix*, *Poa*, soil compressive strength, riparian complex

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